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Short Communication

Report of coloration anomalies in mammals from Panama

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Abstract

Coloration anomalies are widespread across the animal kingdom; however, they pass underreported for some taxa or are extremely rare, like in the case of mammals. Three of those anomalies are albinism, leucism, and erythrism, each of which generates atypical colorations in white with white spots and reddish-brown, respectively. Here, we report five cases of coloration anomalies in mammals from Panama: 1) albinism in the Derby's woolly opossum (*Caluromys derbianus* Waterhouse, 1841), the lowland Paca (*Cuniculus paca* Linnaeus, 1766), and the variegated squirrel (*Echinosciurus variegatoides* Ogilby, 1839). 2) leucism in the Central American agouti (*Dasyprocta punctata* J. E. Gray, 1842), and 3) erythrism in the northern Tamandua (*Tamandua mexicana* Saussure, 1860). We discuss some implications of these observations and the importance of gathering this type of data for developing more complex studies in the future.

Key words: Albinism, erythrism, leucism, Mammalia, melanin

Introduction

It is known that color in mammals is almost exclusively due to the presence or absence of melanin present in the skin, hair, and eyes (Hofreiter and Schöneberg 2010; Ortiz-Hoyos et al. 2020). Atypical colorations occur occasionally due to an excess or deficit in the production of melanin in some body parts or the whole body (Acevedo and Aguayo 2008; Abreu et al. 2013). Some of those atypical colorations include melanism, leucism, albinism, and piebaldism (Abreu et al. 2013).

The term melanism is used to refer to blackened phenotypes (Jackson 1997; Nachman et al. 2003); leucism for phenotypes with atypical white patches

(Veena et al. 2011); white phenotypes with black eyes (Mitchell and Church 2002; Van Grouw 2006; Steen and Sonerud 2012; Moore and Ouellet 2014); and abnormal pale or discolored colorations (Sage 1962; Snyder 1968; Acevedo and Aguayo 2008; Derlindati et al. 2013). For instance, piebaldism is a form of leucism in which the phenotype is characterized by the presence of abnormally light males (Acevedo et al. 2009). There is still some divergence among some authors, mainly because some of the studies do not take into account the differences between piebaldism and leucism (e.g., Geiger and Pacheco 2006; Oliveira 2009). Overall, the term albinism has been widely used to refer to any type of hypopigmentation, and the term piebaldism refers to phenotypes with white spots (Zalapa et al. 2016), which is inappropriate because piebald is one of several genes that produce white spots (Lamoreux et al. 2010). Moreover, another anomaly in coloration is called erythrism, which is characterized by reddish or reddish-brown coloration in the hair or feathers (Bukaciński and Bukaciński 1997; Pirie et al. 2015).

Although leucism is expected to occur in all vertebrate classes, it is a very rare anomaly in natural populations (Camacho et al. 2022, and references therein). In the case of albinism, the phenomenon is extremely rare in vertebrates, especially in mammals (McCardle 2012), and strongly associated with visual and auditory dysfunctions (Creel 2015). On the other hand, there is a lack of information on the generality of erythrism in mammals, and it seems to be more common in non-mammal vertebrates (e.g., Mačát et al. 2016; West and Allain 2020; Hidalgo-Licona et al. 2023). For this reason, it is important to report these anomalies and gather knowledge about the generality of these phenomena and associated variables between mammal species to better understand their occurrence. Here, we present cases in five species of mammals in Panama: albinism in the Derby's woolly opossum (*Caluromys derbianus*), the lowland Paca (*Cuniculus paca*), and the variegated squirrel (*Echinosciurus variegatoides*); erythrism in the northern Tamandua (*Tamandua mexicana*); and a case of leucism in the Central American agouti (*Dasyprocta punctata*).

Methods

Study species

Caluromys derbianus (Derby's woolly opossum) is a medium-sized marsupial with a long tail and a long wool coat, with a total length of 60 to 70 cm and a weight between 200 and 400 grams (Bucher and Hoffmann 1980). The upper body is light gray with orange spots, with some variation from completely gray to completely yellow or orange. There are often three orange spots on the neck and shoulders, between the back and the rump, besides a gray diamond between the shoulders. The underside is creamy white. The ears are large with a light pink coloration. It also possesses a moderately dark brown line on the forehead (Reid 2009). Conservation status: least concern (IUCN).

Cuniculus paca (Lowland paca) is a large, robust rodent with a pig-like body structure and reddish-brown upper parts. Adults weigh between 6 and 12 kg. It usually has three to five rows of white spots along its sides, against a dark gray background, and is one of the few spotted mammals in Central America (Reid 2009). IUCN conservation status: LC (least concern).

Echinosciurus variegatoides (Variegated squirrel) is a medium-sized squirrel with a variety of colors, from dark brown to yellowish gray. The head-and-body length is about 260 mm, with a tail of similar length. The average weight for the species is 500 g (Thorington et al. 2012). In Central America, there are at least eight different color patterns and several intermediate forms (Reid 2009). IUCN conservation status: LC (least concern).

Dasyprocta punctata (Central American agouti) is typically reddish, orange, or yellowish, grizzled with black. The hairs increase in length from the anterior to the posterior part of the body. Adults show body length ranges from 415–620 mm and body weight ranges from 1.3–4.0 kg. They have short ears, and the hind foot has three toes with hoof-like claws (Nowak 1999). IUCN conservation status: LC (least concern).

Tamandua mexicana (Northern tamandua) is a medium-sized anteater with an almost hairless prehensile tail. Adults possess a rare cream or beige coat with a black vest along the thorax and abdomen, while juveniles are rarely completely black or completely yellow. Adults weigh between 3.2 and 5.4 kg and range from 102 to 130 cm in total length. Overall, there are no differences in coloration or weight between males and females (Reid 2009; Navarrete and Ortega 2011). IUCN conservation status: LC (least concern).

Data sampling

The records for *C. derbianus* were obtained from the Eustorgio Méndez Zoological Collection (COZEM) at the Gorgas Memorial Institute of Health Studies and the Vertebrate Museum of the University of Panama (MVUP), where we reviewed samples of marsupials deposited in their collections. Moreover, we present a summary of the literature on color anomalies reported for American marsupials. We used Web of Science (WOS) and Scopus to search for articles about coloration anomalies. We performed independent searches with the terms 'albinism', 'leucism', and 'xanthochromism'. Each of these searches was refined with the terms 'marsupial' or 'didelphis', or 'caluromys'. We followed the standard requirements of systematic reviews as specified by PRISMA (Moher et al. 2009) and selected articles if they contained a species of the American continent with some form of coloration anomaly. One study from our results (McCardle 2012) was obtained from the review by Cuxim-Koyoc et al. (2019) and did not appear in any of the search combinations (Fig. 1).

For *C. paca*, *T. mexicana*, and *E. variegatoides*, we report anecdotal observations. The individual of *C. paca* was hunted (subsistence hunting) by locals in the village Alto de la Montaña (8.957630871, -79.98264601, province of Veraguas, Fig. 2), which is a dry forest area. The albino variegated squirrel was observed near a secondary road that goes along the Pacora River (9.1221176, -79.275775, Fig. 2), in an area with secondary rainforest. A juvenile of *T. mexicana* was observed in Capira, Panamá Oeste province (8.91806, -79.64444, Fig. 2), and an adult in the protected forest of the campus of the Universidad Tecnológica de Panamá (UTP, 9.023569026, -79.53239012, Fig. 2); these latter two sites are also secondary rainforests. The observation of the agouti with leucism was recorded from camera trapping being carried out on the island of Cébaco (7.50397, -81.21594, Fig. 2), where some of the authors carry out experimental work on the agoutis'

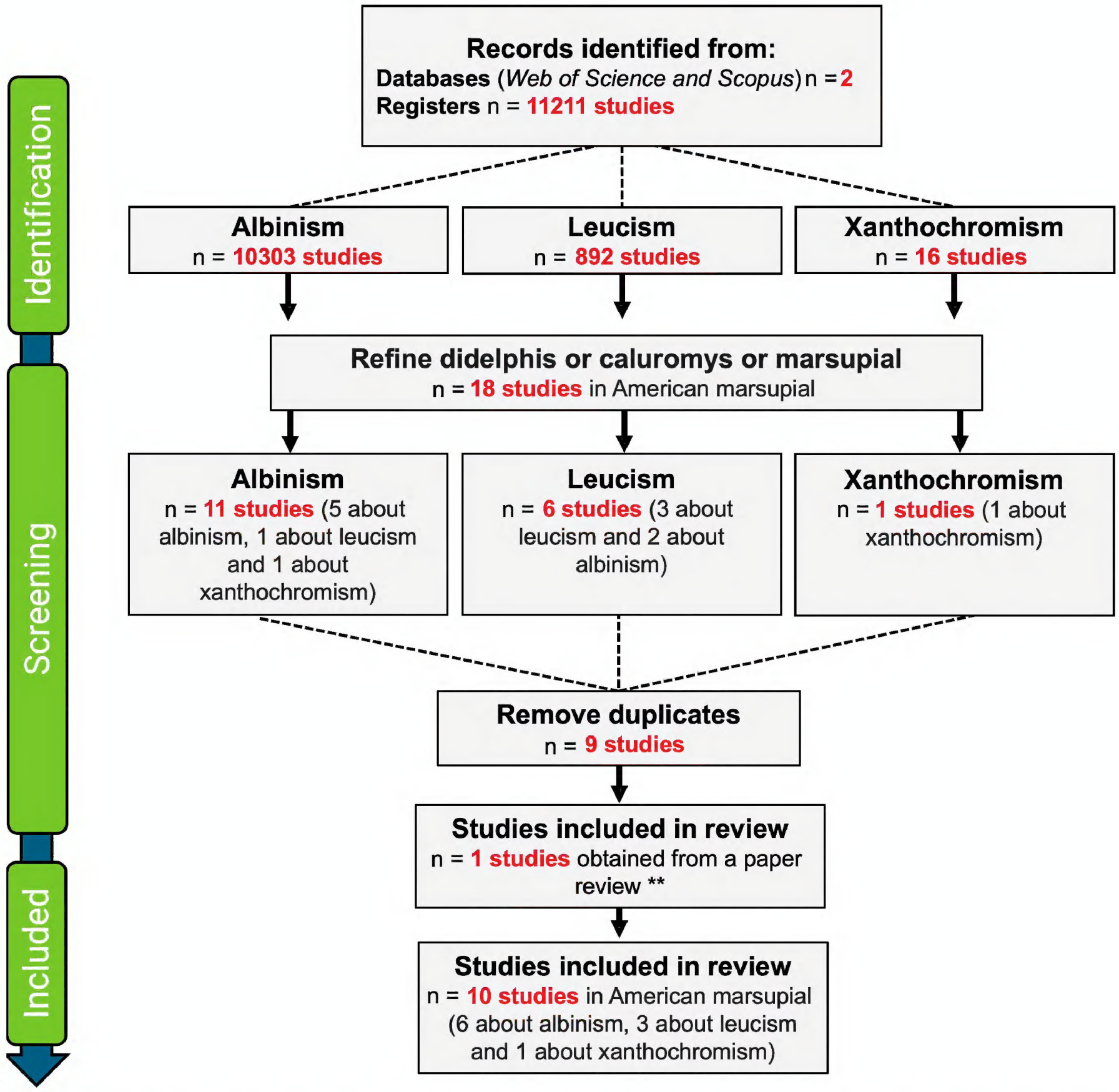
Identification
Screening
Included
Records identified from:
Databases (Web of Science and Scopus) n = 2
Registers n = 11211 studies
Albinism
n = 10303 studies
Leucism
n = 892 studies
Xanthochromism
n = 16 studies
Refine didelphis or caluromys or marsupial
n = 18 studies in American marsupial
Albinism
n = 11 studies (5 about albinism, 1 about leucism and 1 about xanthochromism)
Leucism
n = 6 studies (3 about leucism and 2 about albinism)
Xanthochromism
n = 1 studies (1 about xanthochromism)
Remove duplicates
n = 9 studies
Studies included in review
n = 1 studies obtained from a paper review **
Studies included in review
n = 10 studies in American marsupial (6 about albinism, 3 about leucism and 1 about xanthochromism)

Figure 1. A PRISMA flow diagram showing the procedure followed in our review of coloration anomalies in American marsupials. See Moher et al. (2009) for details about PRISMA.

behavior. In that study, 20 cameras were baited with corn kernels that were placed just in front of the camera during five days (May 14–18, 2023), which represents 100 camera trap days.

Results

At the Eustorgio Méndez Zoological Collection, we found nine samples of *Caluromys derbianus* (five males and four females); eight of them were collected between 1960 and 1970 within the Panamanian territory, and one sample from Colombia was collected in 1967. One of the individuals was albino and was collected in 1970 near the village of Aguacate (8.957630871, -79.98264601, Capira, province of Panama Oeste, Figs 2, 3a). It is worth mentioning that we found an individual with grayish-brown coloration, similar to the subspecies *Caluromys derbianus pallidus*, collected in 1967 (Fig. 3a). At the MVUP, we found seven

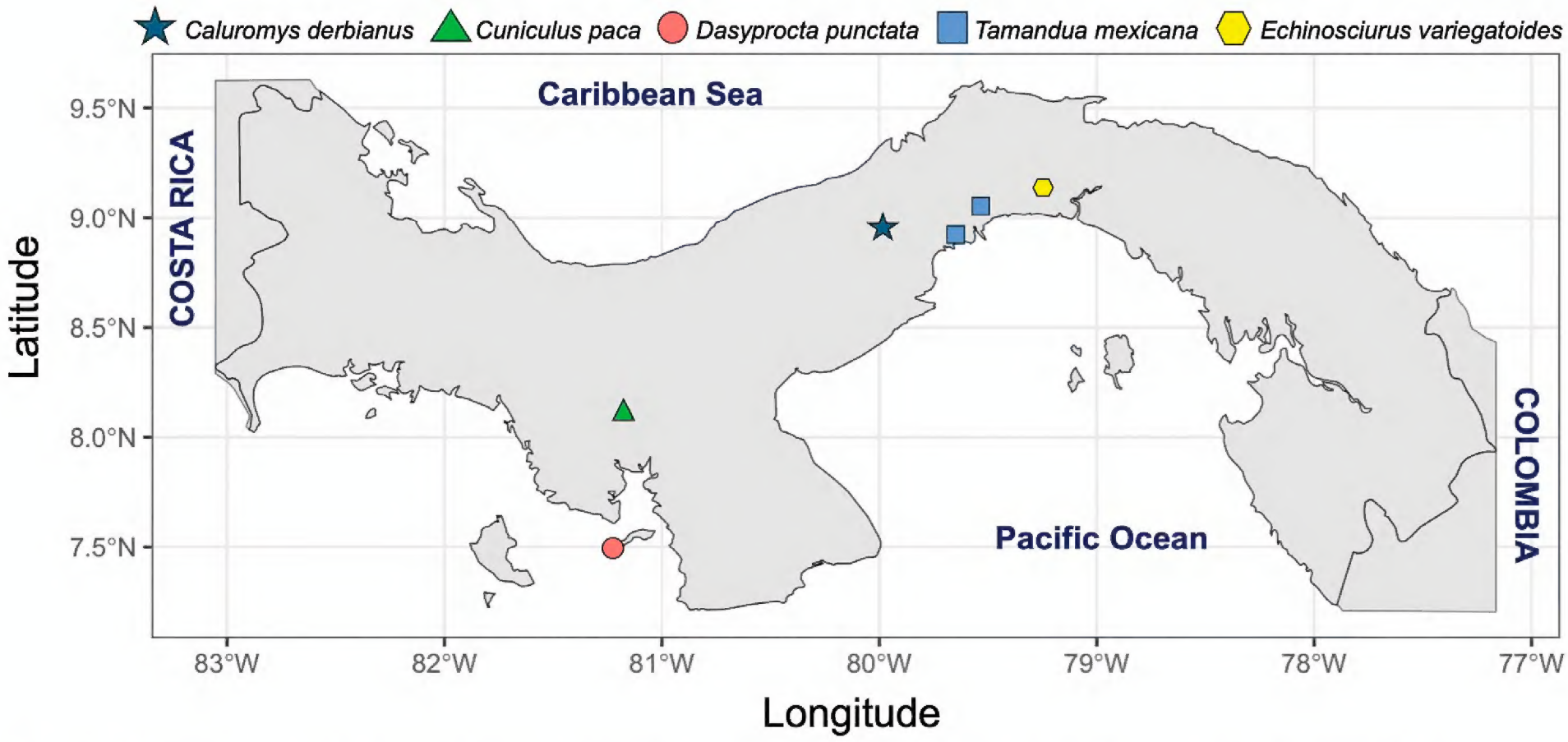

Figure 2. Map of Panama showing the locations of mammals with coloration anomalies reported in this study.

Figure 3. Coloration anomalies in mammals from Panama. Morphotypes of *Caluromys derbianus* at COZEM showing an albino (bottom), the typical reddish brown (center), and an atypical greyish individual (**a**). Albino individual of *Cuniculus paca* that was hunted by locals at the village of Aguacate (**b**) and albino individual of *Echinosciurus variegatoides* observed near the Pacora river (**c** see text for coordinate details). Photo credit: Aracelys De Gracia C. and Roberto Vergara E.

males and seven females, collected in Panama between 1980 and 1993; all of them showed the typical reddish-brown coloration for the species. Besides our report, other five species of marsupials on the American continent have been reported with some form of coloration anomaly, including another anomaly that generates a yellowish coloration called xanthochromism (Table 1).

Table 1. Summary of coloration anomalies reported in marsupials from the American continent.

Study	Species	Cases	Anomaly	Country
Campbell (1981)	*Didelphis virginiana*	1	Albinism	United States
McCardle (2012)	*Didelphis virginiana*	2	Albinism	United States
McCardle (2012)	*Didelphis virginiana*	3	Partial albinism	United States
Abreu et al. (2013)	*Didelphis* sp.	1	Leucism	Brazil
Eckhardt et al. (2013)	*Didelphis albiventris*	1	Leucism	Brazil
Cuxim-Koyoc et al. (2019)	*Didelphis virginiana*	1	Albinism	Mexico
Ortiz-Hoyos et al. (2020)	*Didelphis marsupialis*	1	Leucism	Colombia
Vanstreels et al. (2021)	*Didelphis aurita*	2	Albinism	Brazil
Cotts et al. (2023a)	*Didelphis aurita*	1	Xanthochromism	Brazil
Freire-Filho et al. (2024)	*Didelphis albiventris*	1	Albinism	Brazil
This study	*Caluromys derbianus*	1	Albinism	Panama

We report the first case of albinism for *Cuniculus paca* in Panama, a male weighing 10 kg and 66.7 cm in length (Fig. 3b). Besides, we report the first case of albinism in *Echinosciurus variegatoides*, which was observed on June 6, 2018, by two biologists who shared the picture with us (Fig. 3c).

The observation of two tamanduas (*Tamandua mexicana*) with erythrism would expand the geographical range where the anomaly has been observed in the past (Fig. 4).

Regarding the agouti, to our knowledge, this is the first report of leucism for *Dasyprocta punctata* (Fig. 5). This individual was photographed multiple times and often in the presence of individuals with the typical coloration (Fig. 5).

Discussion

Overall, color anomalies in mammals are probably underreported in the literature, and here we present five cases of mammals from Panama, contributing to understanding the frequency of the occurrence of these anomalies in wild mammal populations. Here we report three novel cases of coloration anomalies in mammals: albinism in *C. derbianus*, albinism in *E. variegatoides*, and leucism in *D. punctata*.

For instance, it seems that atypical colorations are spread across the order Didelphimorphia (McCardle 2012; Abreu et al. 2013; Eckhardt et al. 2013; Cuxim-Koyoc et al. 2019; Ortiz-Hoyos et al. 2020; Vanstreels et al. 2021; Cotts et al. 2023a; Freire-Filho et al. 2024). However, all these reports were made for species within the genus *Didelphis*, and here we report the first case of albinism for the genus *Caluromys*.

In the case of rodents, albinism has been reported in at least 66 species in the world (Romero et al. 2018; García-Casimiro and Santos-Moreno 2020). Our report of albinism in *C. paca* expands the range of distribution of the phenomenon for the species, which was first reported in Mexico in 2017 (García-Casimiro

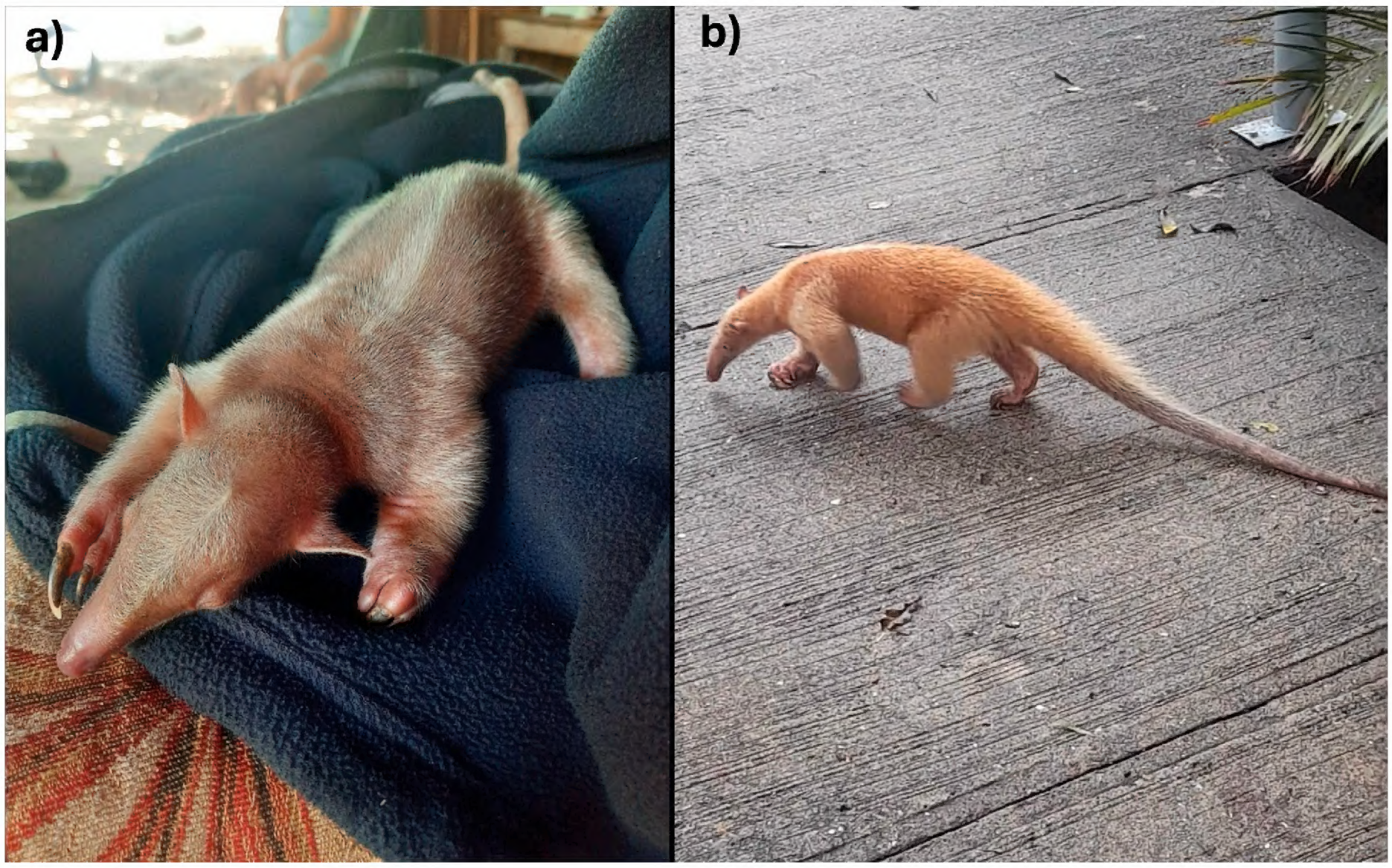

Figure 4. Individuals of *Tamandua mexicana* showing erythrism. A rescued juvenile at Capira (**a**) and an adult on the campus of the Universidad Tecnológica de Panamá (**b**). Photo credit for photograph b: Instagram account of the UTP.

Figure 5. An individual of *Dasyprocta punctata* with leucism on Cebaco Island. The top-right square shows the same agouti consuming corn kernels, together with individuals showing the typical coloration for the species.

and Santos-Moreno 2020). Albinism is the only coloration anomaly that has been reported for lowland pacas, and further work can provide deeper insights into the occurrence of this anomaly in the region.

Albinism in squirrels seems to be geographically spread, with reports from Asia (Sayyed et al. 2015), Central Europe (Hoekstra 2004), Siberia (Serebrennikob 1931), and North America (Ferron 2013). Here, we report the first case of albinism for *E. variegatoides*, a species distributed from Mexico to Panama, and therefore contribute to reporting the occurrence of albinism in rodents in the tropics, which is significantly underrepresented in the literature (Romero et al. 2018). In the case of agoutis, partial albinism was reported for the Azara's agouti in Brazil (*Dasyprocta azarae* Lichtenstein, 1823, Oliveira 2009), leucism in the black agouti from Ecuador (*D. fuliginosa* Wagler, 1832, Mejía Valenzuela 2019), albinism in *D. punctata* from Honduras (Elvir-Valle et al. 2021), and we report the first case of leucism in *D. punctata*. The occurrence of leucism (and albinism) in island populations like Cebaco would suggest that inbreeding and low genetic variability are potential triggers (Prado-Martinez et al. 2013; Brito and Valdivieso-bermeo 2016). Moreover, although atypical colorations like albinism are expected to be disadvantageous in terms of survival chances against predators (Vignieri et al. 2010), it is unclear whether leucism could also be selected against as drastically as albinism. Leucistic phenotypes can present defects that impair sensory organs and nerves (Fleck et al. 2016), which should disfavor their fitness and survival. Related to survival, a security guard in Cebaco mentioned that leucistic agoutis were common in the area, a predator-free site. Therefore, in the absence of predators, this abnormal coloration does not seem to impair their survival as a result of some form of related pathology. Further long-term studies could evaluate whether coloration anomalies are more frequent in isolated populations, isolated from predators, and try to disentangle the genetic and ecological drivers of these anomalies.

Regarding the tamanduas, this genus shows a large range of coloration anomalies on the continent (Cotts et al. 2023b). By adding up our data and previous studies (Cotts et al. 2023b), we indicate that erythrism is the most frequent coloration anomaly in tamanduas in Central Panama. In fact, besides erythrism, only leucism has been observed for *T. mexicana* in Peru (More et al. 2021). An overall estimation of the occurrence of these anomalies in mammals is needed if future studies intend to better understand the variables that drive the occurrence of the anomalies. However, we are aware that such a task is difficult without accurate estimations of the population size of the species of interest.

For that reason, more accurate methods for monitoring cryptic mammals could provide better estimates of the rarity of coloration anomalies. Assembling a large dataset of their occurrence across taxa, geographical regions, and potential explanatory variables can provide significant information for more complex studies (e.g., systematic reviews and meta-analysis). For instance, in squirrels, melanism is significantly higher in urban areas, possibly due to lower predation and abiotic factors (Cosentino and Gibbs 2022).

Conclusions

Coloration anomalies are rare in mammals; therefore, it is important to report them with the goal of understanding the commonality across taxa and consequently the mechanisms driving their occurrence. Here, we provide four novel

observations, including albinism in a marsupial and two rodent species from Panama, besides a case of leucism for the Central American agouti. Additionally, we observed two cases of erythrism in the Northern Tamandua that, together with previous observations, suggest that it is the most common coloration anomaly for this tamandua species in Central Panama. Further work is needed to better understand the genetic and ecological factors driving the expression of these anomalies and their implications.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

All authors contributed to the idea of the manuscript. MC, EP, and JA reviewed the collections and included details about albinism in the opossum. RF and RM included details on the observation about albinism in the paca, and they obtained authorization for the use of the photographs of the tamanduas and squirrels. DMM, BB, RV, and DG carried out field work that resulted in the observations of the leucistic agouti. YA built the map and the PRISMA graph. RF and DG wrote a first draft of the manuscript, and all authors commented and contributed to the edition. All authors approved the last version of the manuscript for submission.

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Data availability

All of the data that support the findings of this study are available in the main text.

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